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16. ABSTRACT The paper discusses the use of EPA's transportable Stretford process pilot plant on a 700-acfm slipstream of in-situ shale oil retort offgas to investigate H_2S removal efficiency and process compatibility. This was the fourth application of the pilot plant which had demonstrated a continuously improving performance. During this test, the pilot plant was operated first with a venturi contactor alone and then with the venturi followed in series by a packed tower contactor. With the venturi alone, the plant achieved 95% removal efficiency, but its average performance was lower. With the addition of the packed tower, the removal efficiency reached 99+%. Excessive foaming of the process solution was experienced which was attributed to the presence of organic aerosol in the retort offgas.

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Hydrogen Sulfide	Stretford Process	07B
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PROCESSING IN-SITU OIL SHALE RETORT OFFGAS WITH A STRETFORD PLANT AT GEOKINETICS

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ABSTRACT

The EPA transportable Stretford process pilot plant was used on a 700 ACFM slipstream of in-situ shale oil retort offgas to investigate H_2S removal efficiency and process compatibility. This was the fourth application of the pilot plant which had demonstrated a continuously improving performance. During this test the pilot plant was operated first with a venturi contactor alone and then with the venturi followed in series by a packed tower contactor. With the venturi alone, the plant achieved 95 percent removal efficiency, but its average performance was lower. With the addition of the packed tower, the removal efficiency reached 99+ percent. Excessive foaming of the process solution was experienced which was attributed to the presence of organic aerosol in the retort offgas.

INTRODUCTION

Oil shale facilities proposed for Colorado and Utah will produce substantial quantities of H_2S and other sulfur gases which could impact Class I airsheds such as the Flattops wilderness area. The Clean Air Act requires stringent control of such emissions through the use of best available control technology under PSD permits. This report provides data characterizing in-situ oil shale offgases from the Geokinetics (Seep Ridge) plant in eastern Utah and assessing the effectiveness of the Stretford process in controlling the emission of H_2S and other sulfur compounds. The results should assist developers and permit writers in selecting appropriate controls for the treatment of oil shale offgases.

The offgas from the horizontal in-situ retort at Geokinetics, in eastern Utah, contains approximately 0.15 percent (1500 ppmv) H_2S, 22 percent CO_2, and 0.10 percent NH_3 in addition to N_2 (60 percent), H_2 (9 percent), CO (5 percent), CH_4 (1.5 percent), and other (2.25 percent). While these percentages are presented on a dry basis, the offgas is actually saturated with moisture. Also present, at levels of 0 to 10 ppmv each, are organic carbon species such as carbonyl sulfide, mercaptans, thiophenes, and carbon disulfide. Lovell, et al. (1982) and Desai, et al. (1983) evaluated various processes and concluded that the Stretford process was a viable candidate for this application. Therefore, a series of feasibility tests were sponsored by the EPA in which a Stretford pilot plant was used to process a 700 ACFM slipstream of retort offgas. This paper presents the results of the fourth and latest test of that pilot plant. A comprehensive test report has been published as "Alkaline and Stretford Scrubbing Tests for H_2S Removal from In-Situ Oil Shale Retort Offgas," EPA Contract 68-03-3166 (Taback, et al., 1985)

Previously the Stretford pilot plant had been used at Occidental Oil Shale, Inc.'s (OXY) Logan Wash oil shale development mine near De Beque, CO (July 1982), at the Geokinetics' in-situ retort in eastern Utah (October 1982), and on a U.S. Bureau of Mines coal gasifier in Minneapolis, MN. The H_2S removal

efficiency was higher on each of these tests than on the previous one. On the coal gasifier test 99+ percent H_2S removal was achieved.

The objectives of this fourth test were to (1) duplicate on retort offgas the 99+ percent H_2S removal efficiency achieved on the gasifier tests and (on achieving that), (2) attempt to explain the low removal efficiency during the 1982 test by deliberately introducing upsetting changes to the plant chemistry and then returning it to the 99+ performance.

The Stretford process is regenerative and converts H_2S in the retort offgas to elemental sulfur. It uses air oxidation to regenerate the chemicals reduced during the offgas treatment. It is a highly selective process in that it removes H_2S with negligible side reactions with CO_2. CO_2, like H_2S, is an acid anhydride and is present in the offgas at much higher concentrations than the H_2S. Therefore, most scrubbing processes must be concerned with selectively scrubbing H_2S in preference to CO_2. The Stretford process is highly selective for H_2S. It has been in use for more than 25 years with nearly 100 plants in operation worldwide on such processes as:

- Coal gasification
- Coke oven gas
- Refinery fuel gas
- SNG (petroleum) plant gas
- Natural and associated gases
- Claus tail gas
- Geothermal power generation
- Carbon disulfide manufacture
- Ore roasting
- Sewage sludge digester gas

Process Description

The process chemistry of the Stretford technology is based on the absorption of H_2S in an alkaline scrubbing solution and subsequent liquid-phase oxidation of the captured H_2S to elemental sulfur. The Stretford liquor is a dilute solution of sodium carbonate (Na_2CO_3), sodium metavanadate ($NaVO_3$), and sodium salts of the 2:6 and 2:7 isomers of anthraquinone disulfonic acid (ADA). The solution is maintained at a pH of 8.5 to 9.5 and a temperature of approximately 43°C.

Removing the H_2S from the gas stream and converting it to elemental sulfur is basically a six-step process, as follows (with simplified chemical reactions):

1. The H_2S is absorbed in the alkaline Stretford solution in a suitable gas/liquid contactor.

2. The H_2S reacts with the sodium carbonate to form sodium hydrosulfide and sodium bicarbonate:

$$H_2S + Na_2CO_3 \rightarrow NaHS + NaHCO_3 \quad (1)$$

3. The hydrosulfide then reacts with sodium metavanadate to form elemental sulfur, a quadravalent vanadium salt, and sodium hydroxide:

$$2NaHS + 4NaVO_3 + H_2O \rightarrow Na_2V_4O_9 + 2S + 4NaOH \quad (2)$$

4. The quadravalent vanadium salt then reacts with ADA to regenerate the sodium metavanadate:

$$Na_2V_4O_9 + 2NaOH + H_2O + 2ADA \rightarrow 4NaVO_3 + 2ADA \cdot 2H \quad (3)$$

5. The sodium hydroxide and sodium bicarbonate reaction products further react to form sodium carbonate:

$$NaOH + NaHCO_3 \rightarrow Na_2CO_3 + H_2O \quad (4)$$

6. The reduced ADA reacts with oxygen to regenerate the ADA:

$$2ADA \cdot 2H + O_2 \rightarrow 2ADA + 2H_2O \quad (5)$$

The overall process reaction can be written as the oxidation of H_2S to elemental sulfur:

$$2H_2S + O_2 \rightarrow 2S + 2H_2O \quad (6)$$

Several side reactions that form nonregenerable compounds, primarily oxidized sulfur compounds such as sodium sulfate and sodium thiosulfate, are possible in the Stretford process. These nonregenerable compounds can build up in the system and eventually impede the performance of the process by interferring with the principal chemical reactions. These compounds must be removed from the process either by purging them from the system or by recovering them in a regeneration system.

The oxidized sulfur compounds form when the dissolved oxygen in the process liquor is too high, which occurs when the pH is too low. H_2S absorption is also reduced at low pH. The high CO_2 found in retort offgas can reduce the pH unless the process pH level is maintained by sodium bicarbonate addition.

Figure 1 presents a simplified process flow diagram of the pilot plant. This diagram depicts the basic design configuration of the plant, including a variable throat venturi scrubber gas/liquor contactor, reaction tank, oxidizer, pump tank, and slurry tank. At Geokinetics, before the retort offgas stream entered the Stretford plant, it was conditioned in vacuum blower and mist elimination equipment to remove residual product oil and water. Thus, an attempt was made to preclean the gas stream prior to its entering

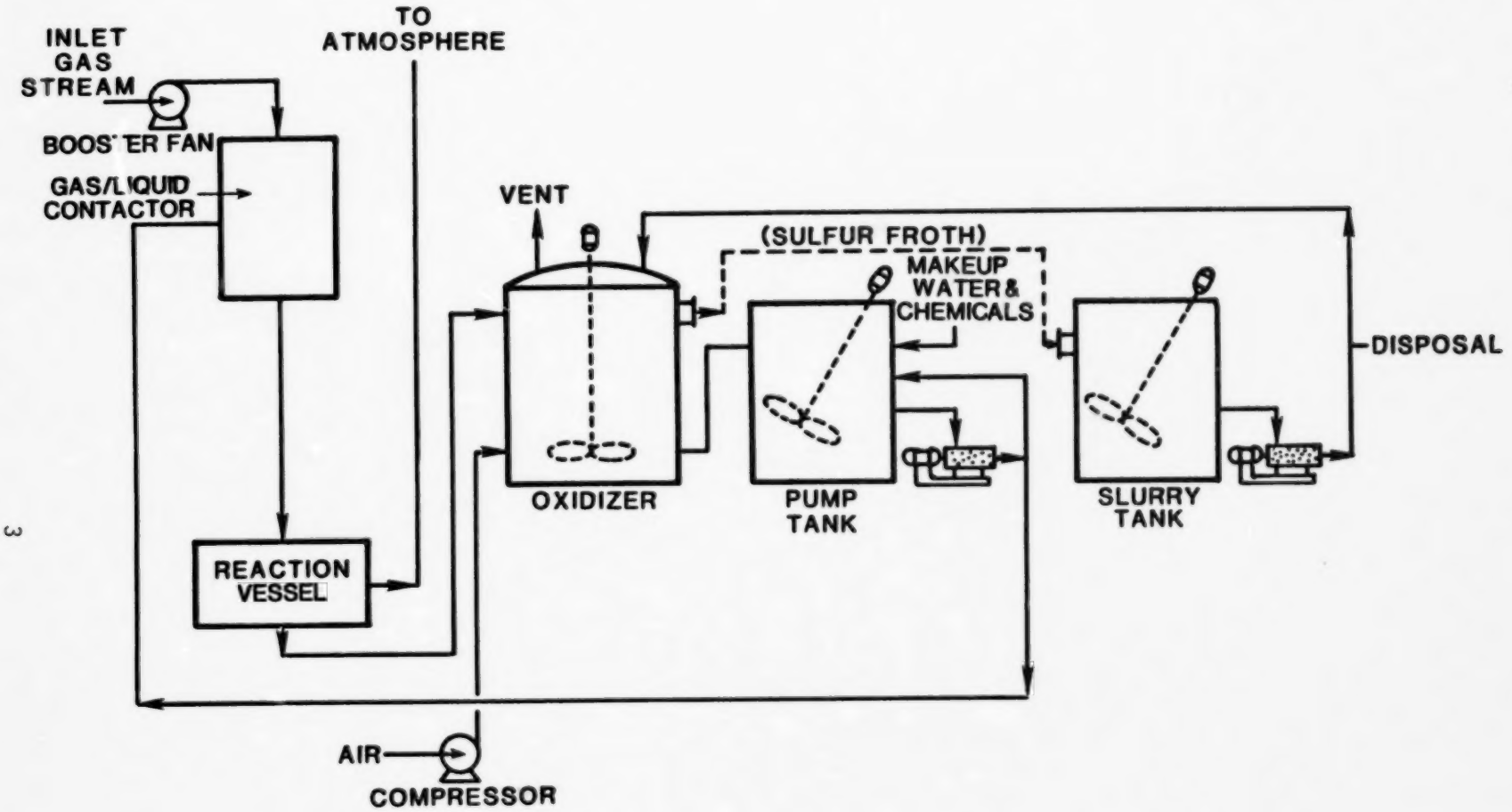

Figure 1. Simplified Flow Diagram of the Stretford Pilot Plant

the Stretford. The Stretford also had a knockout tank to collect oil and water which further condensed on the walls of the inlet pipeline.

The retort offgas stream first enters a venturi scrubber, where the gas comes in contact with the Stretford solution. The solution is delivered to the top of the venturi through a single feed line with a spray nozzle.

The plant was modified during the test to add a 30-cm-diameter packed tower scrubber containing 2.5-cm-diameter Raschig rings. The packed tower was located downstream of the venturi. It provided a much longer gas/liquid contact time. The venturi solution was sprayed into the top of the tower and drained into the reaction tank. Figure 2 shows the installation of the venturi and packed tower.

The reduced process liquor flows from the reactor to the oxidizer (Figure 1). The function of the oxidizer is to reoxidize the Stretford liquor (replenish the reduced ADA), separate the sulfur product from the liquor by air flotation, strip bicarbonate formed in the process from the liquor (as carbon dioxide), and strip any ammonia absorbed from the gas stream. The stripped carbon dioxide and ammonia are removed from the process via an atmospheric vent stack in the oxidizer. Oxidation air is introduced into the base of the oxidation tank through a dispersion ring. The air is further dispersed into the liquid by a mixer. The sulfur product is generated as a froth at the top of the oxidizer. This froth contains approximately seven percent (by weight) sulfur. The froth overflows a slurry weir into the slurry tank.

RESULTS

The Stretford pilot plant was operated for 200 hours. Three sampling and analysis systems were used to characterize the retort offgas both upstream and downstream of the plant. The first system measured reduced sulfur compounds according to EPA Methods 15 and 16 (40 CFR 60, Appendix A, July 1, 1982) which employs a gas chromatograph (GC) with a flame photometric detector (FPD). This system analyzed the gas for hydrogen sulfide (H_2S), carbonyl sulfide (COS), carbon disulfide (CS_2), methyl mercaptan (MeSH), and thiophenes. The GC/FPD was a Perkin-Elmer Model 990, equipped with a ten-port valve for automatic injection of the sample from the sample loop. For backflushing, this unit has a precolumn that traps high-molecular-weight sulfur and hydrocarbon compounds. A continuous offgas sample is taken, bubbled through a cold scrubbing solution (citrate buffer), to remove SO_2 and diluted with clean, dry air. An aliquot of the diluted gas was then analyzed by the GC/FPD.

The second system was a continuous real-time measure of total reduced sulfur (TRS) in the retort offgas. The sample stream was passed through the cold scrubbing solution to remove CO_2, diluted with air, oxidized in a tube furnace, and then passed through a TECO continuous SO_2 monitor. This method was derived from EPA Method 15A (40 CFR 60, Appendix A, July 1, 1982). The readout was calibrated in units of H_2S since there was little organic sulfur present in the offgas.

The third system measured non-sulfur gases using a Baseline Industries, Inc. Model 1030-A GC with a thermal conductivity detector.

Table 1 summarizes the operating conditions and the plant's H_2S removal efficiency recorded throughout the test. The high water and oil vapor content of the retort offgas caused the lines to both sampling systems to clog frequently, limiting the number of removal efficiency measurements that could be made. The removal efficiency in Table 1 was computed from data obtained from the TRS measurements. For the first seven days the H_2S removal efficiency averaged 80 percent and on May 6 and 8 reached a high, approaching 95 percent. When the packed tower was added on May 12 the removal efficiency stepped up to 99+ percent which was sustained for ten hours. The flow to the tower was discontinued to verify that it was the use of the packed tower which produced the 99+ efficiency. This was confirmed when the efficiency dropped to 86 percent. Two days later the scrubbing solution was again supplied to the tower, returning the unit to a higher efficiency which had reached 99 percent when the test was terminated due to a Geokinetics plant shutdown.

The daily reduced sulfur species data are summarized in Table 2. These data were measured using the GC/FPD technique. This table shows good agreement between the GC/FPD values for H_2S concentration and the TRS values for H_2S in Table 1. The H_2S removal efficiencies computed by the two methods also agree well. Table 2 also shows the small concentration of organic sulfur species in the offgas. The scatter in the organic species data illustrates the difficulty in measuring these species in such small concentrations. It is believed that there was no significant change in concentration between inlet and outlet for these species.

Discussion of Results

The original objective of achieving and maintaining a 99+ percent H_2S removal efficiency on retort offgas was not achieved with the original plant configuration and operating procedures. Attempts to adjust operating parameters (e.g., decreasing the venturi throat area and increasing the residence time of the solution in the reaction vessel) did not produce any significant change in H_2S removal. Nevertheless, when the gas-to-liquid contact time was increased by adding the packed tower, the 99+ percent efficiency was obtained and maintained for ten hours.

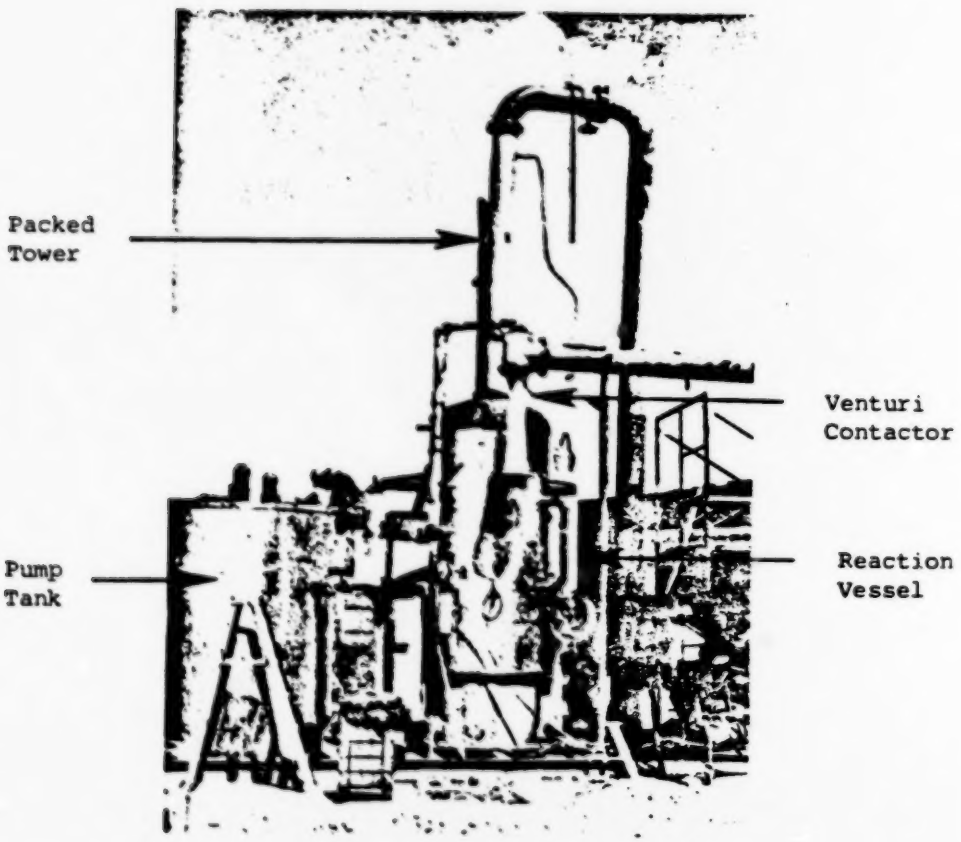

Figure 2. Overall View of Stretford Plant Installed at GKI.

TABLE 1. STRETFORD OPERATING CONDITIONS AND REMOVAL EFFICIENCY DURING GEOKINETICS TEST PROGRAM

Date 1984	Time	Gas Contct Device	Removal Eff %	Gas Flow Rate Sm^3/s	Gas Out Temp °C	Gas Inlt Pres mm Hg	Inlt H_2S Conc ppmV	Out H_2S Conc ppmV	Sol Flow Rate Sl/s	Sol Htr T in °C	Sol Htr T out °C	Oxidizer Air Flow Sm^3/s	Oxidizer Motor Curr amps	ADA Conc kg/m^3	Van. Conc kg/m^3	Carb. Conc kg/m^3	Thio-sul. Conc kg/m^3	pH	Oxidation Potential mV
5/5	18:05	V	75.2	0.190	40	27.8	1617	401	1.93	43	40	0.036	7.5	7.5	2.3	16.8	0.2	10.8	+38
	18:55	V	74.7	0.255	41	30.4	1579	400	1.91	43	43	0.035	7.3	7.5	2.2	16.4	0.2	10.5	+19
	20:30	V	73.7	0.233	43	30.4	1633	429	1.79	44	44	0.029	7.4	7.5	2.2	15.8	0.2	10.2	0
	21:45	V	62.1	0.256	40	30.4	1571	595	1.77	43	43	0.029	7.4	8.7	2.5	15.3	0.2	9.9	-21
	22:35	V	51.7	0.269	43	30.4	1322	639	1.86	46	44	0.026	7.3	8.7	2.4	14.9	0.2	9.9	-15
	23:30	V	61.3	0.269	44	32.9	1618	626	1.54	47	47	0.026	7.3	8.7	2.4	14.5	0.2	9.9	-8
5/6	00:30	V	72.7	0.272	44	29.3	1623	443	1.60	47	47	0.026	7.3	8.7	2.4	14.1	0.2	9.8	-2
	01:30	V	79.5	0.192	38	29.9	2169	444	1.48	47	41	0.026	7.4	8.6	2.4	13.7	0.2	9.8	+5
	02:30	V	90.3	0.327	44	24.3	2018	195	1.48	46	46	0.025	7.4	8.6	2.3	13.3	0.2	9.1	+4
	03:30	V	93.4	0.254	45	30.4	1886	125	1.51	46	46	0.024	7.3	8.6	2.3	12.9	0.2	8.4	+2
	04:25	V	94.3	0.189	46	30.4	1741	100	1.48	47	47	0.024	7.3	8.5	2.3	12.5	0.3	7.7	+1
	05:30	V	93.7	0.189	47	30.9	1590	101	1.50	48	47	0.026	7.3	8.5	2.2	12.0	0.3	7.0	0
5/7	21:21	V	63.0	0.276	46	60.1	763	282	1.67	46	46	0.039	7.5	10.0	3.3	16.0	0.5	10.0	-50
	22:02	V	70.4	0.206	43	65.8	1157	343	1.64	47	46	0.038	7.4	9.9	3.3	15.9	0.5	9.9	-37
5/8	18:23	V	84.5	0.280	42	43.0	1369	212	1.80	43	41	0.038	7.5	8.2	3.3	30.0	0.6	7.4	-39
	20:00	V	94.5	--	--	--	1372	75	--	--	--	--	--	8.0	3.3	30.2	0.6	7.4	-33
	22:05	V	76.8	--	--	--	1378	320	--	--	--	--	--	7.7	3.3	30.4	0.6	7.4	-27
	22:17	V	81.1	0.483	37	53.1	1392	263	1.74	39	36	0.030	7.4	7.6	3.3	30.4	0.6	7.4	-21
	23:12	V	80.2	0.489	37	70.8	1395	276	1.71	39	34	0.034	7.4	7.5	3.3	30.5	0.6	7.8	-21
	23:45	V	80.8	0.443	37	60.7	1398	269	1.73	39	34	0.034	7.4	7.4	3.3	30.6	0.6	8.2	-21
5/9	00:45	V	81.4	0.443	36	65.8	1399	260	1.72	39	35	0.034	7.3	7.3	3.3	30.7	0.6	8.9	-21
	16:10	V	85.6	0.208	42	140.2	1689	243	1.81	43	43	0.039	7.3	4.6	3.2	30.1	0.7	9.1	-69
	16:30	V	82.8	0.218	42	146.7	1700	293	1.82	43	43	0.038	7.3	4.6	3.2	30.1	0.7	8.9	-78
	18:02	V	86.1	0.215	42	126.5	1818	253	1.82	43	43	0.038	7.4	4.6	3.2	29.9	0.7	8.6	-87
	20:20	V	82.7	0.205	42	126.5	1768	306	1.90	43	43	0.038	7.4	4.6	3.2	29.6	0.7	9.9	-75
5/10	00:30	V	82.9	--	39	32.9	1761	301	1.93	43	39	0.030	7.4	5.5	3.5	31.5	0.7	9.7	-42
	17:16	V	80.7	0.189	38	15.2	1362	263	1.36	41	39	0.025	7.7	9.9	3.4	30.1	0.8	9.4	-54
	17:48	V	80.8	0.247	38	15.2	1330	255	1.36	41	39	0.024	7.7	9.9	3.4	29.9	0.8	9.4	-48
	18:27	V	80.9	0.190	37	15.2	1305	249	1.36	40	39	0.024	7.7	9.8	3.4	29.8	0.8	9.5	-42
	19:30	V	81.1	0.267	40	15.2	1283	243	1.35	41	42	0.024	7.7	9.7	3.4	29.5	0.8	9.5	-46
	20:15	V	81.1	0.298	40	15.2	1270	240	1.36	41	42	0.020	7.7	9.7	3.3	29.3	0.8	9.4	-51
	21:28	V	80.9	0.189	40	15.2	1259	240	1.36	42	42	0.019	7.7	9.6	3.3	28.9	0.8	9.4	-55
	22:15	V	81.3	0.220	41	17.7	1255	235	1.36	43	43	0.019	7.8	9.5	3.3	28.7	0.8	9.5	-51
	23:21	V	81.0	0.189	42	17.7	1250	237	1.38	44	44	0.019	7.7	9.5	3.3	28.4	0.8	9.7	-48

V = venturi

TABLE 1. CONTINUED

Date 1984	Time	Gas Contct Device	Removal Eff %	Gas Flow Rate Sm^3/s	Gas Out Temp °C	Gas Inlt Pres mm Hg	Inlt H_2S Conc ppmV	Out H_2S Conc ppmV	Sol Flow Rate Sl/s	Sol Htr T in °C	Sol Htr T out °C	Oxidizer Air Flow Sm^3/s	Oxidizer Motor Curr amps	ADA Conc kg/m^3	Van. Conc kg/m^3	Carb. Conc kg/m^3	Thio-sul. Conc kg/m^3	pH	Oxidation Potential mV
5/11	00:30	V	81.2	N/A	42	12.7	1248	235	1.36	43	44	0.024	7.7	9.4	3.3	28.1	0.8	9.8	-44
	01:30	V	79.7	N/A	39	12.7	1134	230	1.36	43	41	0.019	7.7	9.3	3.3	27.8	0.8	10.0	-41
	02:30	V	80.7	N/A	39	12.7	1250	241	1.36	43	41	0.027	7.7	9.2	3.3	27.5	0.8	10.1	-37
	03:30	V	80.6	N/A	39	12.7	1232	239	1.38	43	41	0.017	7.7	9.1	3.3	27.3	0.8	9.9	-23
	04:35	V	81.8	N/A	40	12.7	1242	226	1.67	42	42	0.017	7.7	9.1	3.2	27.0	0.8	9.6	-10
	05:30	V	81.3	N/A	40	10.1	1240	232	1.53	42	41	0.021	7.7	9.0	3.2	26.7	0.8	9.4	+4
	06:35	V	84.3	N/A	39	10.1	1236	194	2.12	43	41	0.021	7.7	8.9	3.2	26.7	0.8	9.4	0
5/12	13:30	V&T	99.1	N/A	38	19.5	1024	9	1.63	42	42	0.026	7.8	7.5	3.0	30.9	1.0	9.3	+2
	14:30	V&T	99.2	N/A	41	19.5	1036	8	1.64	43	45	0.027	7.8	7.5	3.0	30.7	1.0	9.3	-15
	15:30	V&T	99.1	N/A	38	18.2	985	9	1.60	42	42	0.029	7.7	7.4	2.9	30.4	1.0	10.1	-15
	16:22	V&T	98.8	N/A	38	25.3	1001	12	1.59	42	43	0.029	7.5	7.3	2.9	30.2	1.0	10.8	-16
	17:19	V&T	98.7	N/A	38	22.8	1138	15	1.61	42	42	0.029	7.7	7.3	2.9	30.0	1.0	11.6	-16
	18:25	V&T	98.8	N/A	39	22.8	1199	14	1.62	42	43	0.027	7.7	7.2	2.8	29.7	1.0	12.3	-17
	19:19	V&T	99.1	N/A	39	25.3	1171	11	1.69	42	43	0.031	7.7	7.1	2.8	29.5	1.0	11.5	-22
	20:18	V&T	99.0	N/A	38	25.3	1218	12	1.70	42	42	0.031	7.7	7.1	2.7	29.3	1.0	10.7	-27
	21:25	V&T	99.3	N/A	39	25.3	1237	9	1.86	42	42	0.033	7.6	7.0	2.7	29.0	1.0	9.9	-32
	22:24	V&T	99.4	N/A	100	27.8	1232	8	1.96	43	41	0.035	7.5	6.9	2.6	28.7	1.0	9.8	-23
	23:21	V&T	99.4	N/A	39	25.3	1228	7	2.05	42	41	0.035	7.6	6.8	2.6	28.5	1.0	9.6	-13
5/13	15:30	V*	86.9	N/A	38	20.0	990	130	1.88	39	41	0.042	7.6	7.6	2.1	--	1.1	9.9	-9
	16:12	V*	84.3	N/A	39	25.3	797	125	1.86	41	41	0.043	7.6	9.7	2.8	--	1.1	10.1	-19
	17:17	V*	83.3	N/A	39	25.3	749	125	1.79	42	42	0.044	7.6	9.7	2.7	--	1.1	10.4	-28
	18:57	V*	85.4	0.250	39	25.3	940	137	1.82	40	41	0.043	7.6	9.7	2.6	--	1.1	10.6	-23
	19:32	V*	86.2	0.251	38	25.3	1001	138	1.86	40	42	0.039	7.7	11.0	3.0	--	1.1	10.7	-18
	20:16	V*	86.9	0.251	38	25.3	1063	139	1.83	42	42	0.038	7.6		3.0	--	1.1	10.9	-13
	21:13	V*	87.3	0.251	38	25.3	1094	139	1.83	43	43	0.037	7.6		3.0	--	1.1	--	--
	22:18	V*	87.4	0.250	39	26.3	1113	140	1.87	43	43	0.036	7.6		2.9	--	1.1	--	--
	23:25	V*	87.6	0.250	39	22.8	1119	139	1.82	44	43	0.036	7.6		2.9	--	1.1	--	--
5/14	00:00	V*	87.7	0.250	38	22.8	1125	138	1.83	44	43	0.036	7.6	11.0	2.8	--	1.1	--	--
	01:00	V*	87.9	0.211	36	22.8	1133	137	1.80	40	38	0.033	7.6	11.0	2.8	--	1.1	--	--
	02:00	V*	87.9	0.210	36	22.8	1133	137	1.77	40	41	0.031	7.6	11.0	2.7	--	1.1	--	--
	03:00	V*	88.3	0.210	36	22.8	1128	132	2.02	41	42	0.031	7.6	11.0	2.7	--	1.1	--	--
	04:00	V&T	95.1	0.210	37	22.8	1116	55	2.08	41	42	0.028	7.6	11.0	3.1	--	1.1	--	--
	05:00	V&T	95.0	0.210	36	22.8	1127	56	2.05	38	37	0.031	7.6	11.0	3.0	--	1.1	--	--
	06:00	V&T	94.5	0.210	37	22.8	1115	61	2.05	40	39	0.033	--	11.0	3.0	--	1.1	--	--
	07:00	V&T	94.4	0.192	37	22.0	1106	62	2.27	39	39	0.033	7.6	11.0	2.9	--	1.1	--	--
	07:30	V&T	97.3	0.182	37	17.5	1101	30	2.26	39	39	0.034	7.7	--	--	--	1.1	--	--
	08:15	V&T	98.7	0.182	--	17.5	1091	14	2.26	39	39	0.034	7.7	--	--	--	1.1		

V = venturi
V&T = venturi plus packed tower

* On these tests, the packed tower was in place but no solution was flowing to it.

TABLE 2. REDUCED SULFUR SPECIES EMITTED (ppm)**

Date 1984	H_2S Concentration Inlet Avg	Inlet Range	Outlet Avg	Outlet Range	Remvl Eff. Avg	COS Concen. Inlet	COS Concen. Outlet	MeSH Concen. Inlet	MeSH Concen. Outlet
5/5	1584	1322-1730	447	385-693	72	45	59	N.D.*	N.D.
5/6	1719	776-2165	261	16-559	85	190	36	N.D.	7
5/8	1377	1367-1898	244	75-395	82	N.D.	54	N.D.	5
5/9	1638	1398-1935	278	188-343	83	35	82	N.D.	4
5/10	1314	1245-1761	248	235-301	81	N.D.	53	N.D.	N.D.
5/11	1144	1015-1253	228	190-240	80	26	52	N.D.	N.D.
5/12	1141	953-1249	10	6-15	99	99	72	N.D.	14
5/13	981	718-1125	131	7-140	87	88	76	N.D.	18
5/14	1121	1091-1137	92	14-138	92	94	79	N.D.	18

* N.D. = none detected, minimum detectable level.

** GC/FPD measurements

Whether or not a packed tower is the most desirable contactor for the Stretford process was not resolved on this test. Other types of contactors (e.g., a tray tower, multiple venturi stages) may also be effective. The packed tower could eventually become a maintenance problem if sulfur or particulate matter in the retort offgas were to collect. This test was insufficient to investigate this aspect of the packed tower performance.

It is, however, reasonable to conclude that if a venturi contactor fails to provide the desired H_2S removal efficiency on a Stretford plant, then changing the contactor to increase contact time should increase the removal efficiency.

During the test, one episode (on May 10) of excessive foaming was experienced in the slurry tank (Figure 1). An antifoaming agent was added at frequent intervals, the oxidized air flow was reduced, and the solution flow from the slurry tank to the oxidizer tank was increased to prevent the slurry tank from overflowing. Eventually the foaming was brought under control when the apparent cause was discovered. This upset in the solution had no noticeable effect on the H_2S removal as can be seen in Tables 1 and 2.

The foam was attributed to excessive amounts of shale-oil-laden condensate water carried into the process by the retort offgas. A liquid knockout tank was provided upstream of the system as mentioned above. When the foaming began, it was discovered that the knockout tank was filled and the overflow was being carried into the process. When the tank was drained and the above antifoaming measures were taken, the process was restored to normal.

CONCLUSIONS

Based on this test the following conclusions were reached:

1. With an adequate contactor, the Stretford process can obtain removal efficiencies of 99 percent or higher on retort offgas. If adequate H_2S removal cannot be achieved with a venturi, then a packed tower or other method for increasing contact time should be considered for improving performance.

2. To ensure satisfactory performance of a Stretford plant in processing retort offgas, it is important to provide effective removal of hydrocarbon mist and other particulate matter from the gas before it enters the plant.

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